THE WEATHER AND CIRCULATION OF NOVEMBER 1966

A Mild Month With Two Intense Midwest Storms and a Record Early Cold Spell

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1. MEAN CIRCULATION AND HIGHLIGHTS

The mean hemispheric 700-mb. circulation of November 1966 was characterized by strong ridges in the Aleutians and in the north-central Atlantic (figs. 1 and 2). The Low usually found near Baffin Island was deeper than normal, representing a relaxation of the blocking observed the previous month [1]. Below normal heights associated with vigorous troughs were also found over a large part of eastern Asia, near the west coast of the United States, and over the western European-Mediterranean area. The abnormally short wavelength between the eastern Pacific and Midwest troughs suggests the latter may have been at least partially an orographically induced feature associated with abnormally strong westerly flow across the Northern Rockies.

As often happens when heights are above normal at high or middle latitudes over the oceans, there were compensating areas of below normal heights at low latitudes across the entire Atlantic and most of the Pacific. An unusual number of storms developed in these areas, particularly in the Atlantic. Several of the disturbances displayed tropical characteristcis at times, and water temperatures were above normal. The area of positive height anomaly for November 1966 was a little farther north and similar to Ballenzweig's composite chart of mean height anomaly for months during which at least two tropical storms developed in the eastern Atlantic (see fig. 5 of [2]).

It is interesting to note that although the actual hemispheric wave number was predominantly three at high latitudes and six or seven at low latitudes (fig. 1) the height anomaly pattern (fig. 2) indicates a nearly hemisphere-wide *anomaly* pattern of wave number three. In areas where this pattern reinforced normal or existing troughs, as in Europe, extreme weather events occurred, such as the devastating floods in northern Italy. In areas where the anomaly pattern was out of phase with the usual ridges and troughs, normal features were displaced or did not occur at all. There was no Aleutian Low as such, but a full-latitude trough was observed off the west coast of North America (fig. 1). One lobe of the anomalous wave number three pattern was in phase with the Asiatic coastal trough, which was stronger than normal at high and middle latitudes (fig. 2).

These effects are also shown quite well in figure 3. From October to November, the anomaly of 700-mb. height decreased by 600 ft. just north of the Sea of Okhotsk and increased by 540 ft. over the central Aleutians. The changes over the Atlantic were zonally oriented, with rises at middle to high latitudes and falls at low latitudes. Little change was observed over Europe, much of which was abnormally stormy in October also.

The most noteworthy weather events of November 1966 in the United States are barely hinted at by the monthly mean patterns discussed thus far, since several contrasting regimes made up the month's weather. During the first week of the month and again at the end, the planetary waves over North America amplified and deep storms moved into the Great Lakes area bringing high winds and heavy precipitation with cold air in their wake. Although the storm at the end of the month was more violent, the disturbance in the first week was more extreme in an anomalous sense, producing record early season snowfalls over large sections of the Ohio and Tennessee Valleys and setting several low temperature records for so early in the season in the Midwest and South.

During the period between these two storms, mild Pacific and at times Gulf air flooded the country, producing generally pleasant weather and two unusually warm periods during which many records for daily maximum temperatures were broken.

2. TEMPERATURE AND PRECIPITATION

The anomalous 700-mb. flow pattern in figure 2 suggests a mild month over most of the country, with stronger than normal maritime trajectories and southerly components along much of the Atlantic and Pacific coasts, above normal heights over New England and the Southern Rockies, and no abnormal component of flow from Canada. The departure from normal of the monthly mean 1000–700-mb. thickness (fig. 5) is very well correlated with the observed surface temperature anomaly pattern for November (fig. 6). Arctic air was for the most part contained in Canada, with coldest weather in the United States over the Northern Plains, where monthly mean temperatures were more than 8° F. below normal near the Canadian border. In Canada, temperatures were extremely low, remaining far below zero for

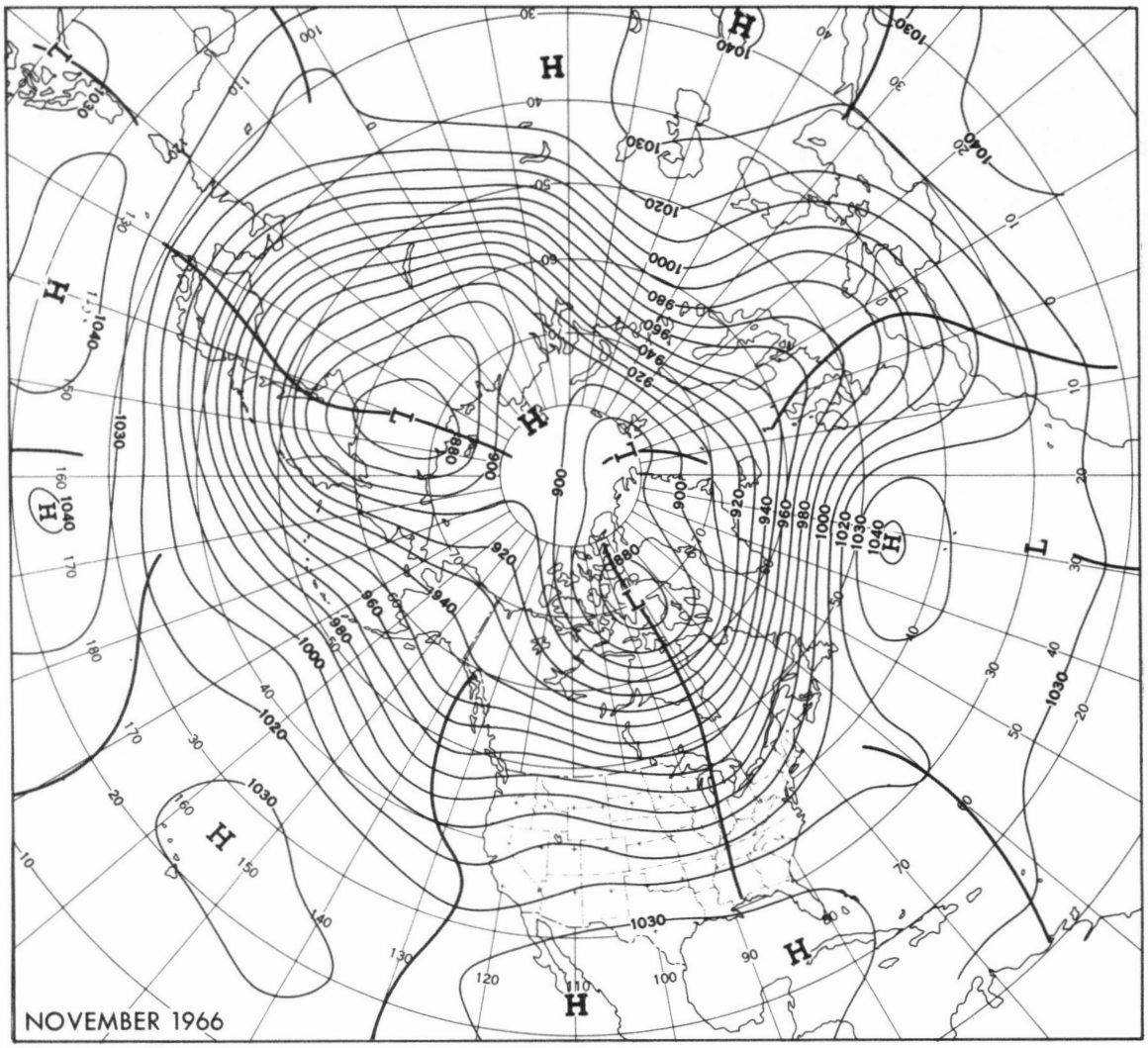


FIGURE 1.—Mean 700-mb. contours (tens of feet) for November 1966. Heavy and in some cases record precipitation occurred east of the troughs over the Ohio Valley and western Mediterranean.

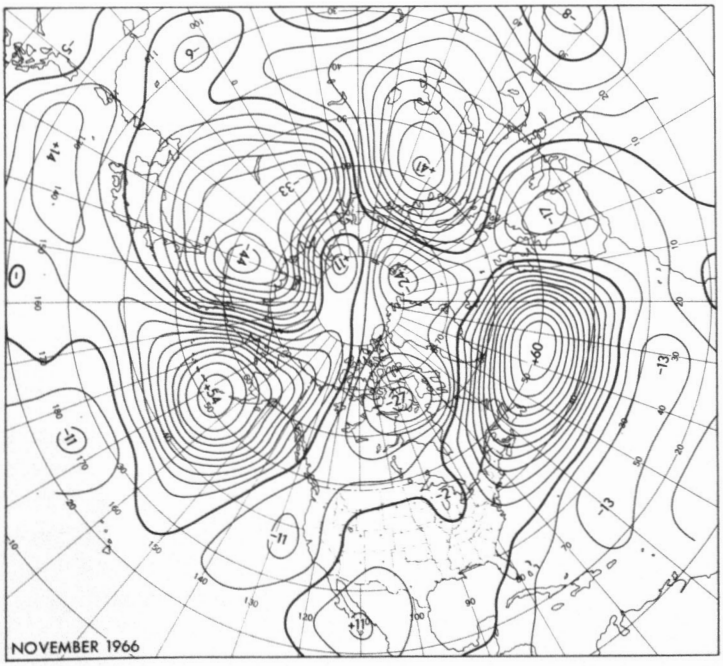


FIGURE 2.—Departure of mean 700-mb. heights from normal (tens of feet) for November 1966. Note extremely strong centers of above normal height near 50° N. over the Pacific and Atlantic.

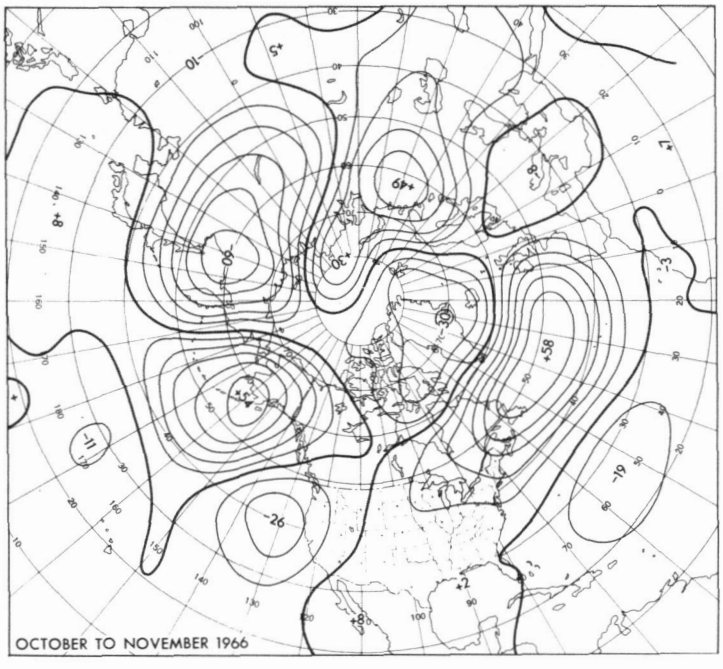


FIGURE 3.—Mean 700-mb. height anomaly change (tens of feet) from October to November 1966. Height falls over the Sea of Okhotsk were associated with rapid development of the cold-season Asiatic coastal trough.

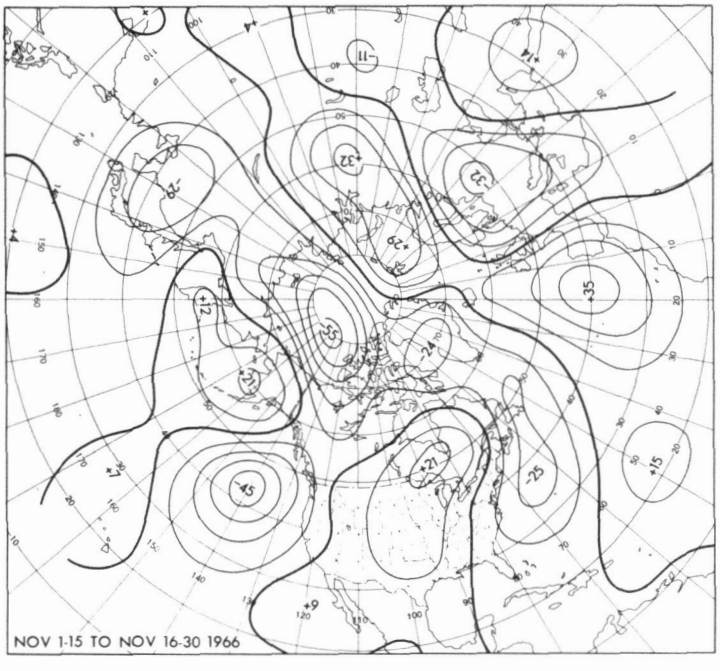


FIGURE 4.—Change of 700-mb. height (tens of feet) from first half to second half of November 1966. Height rises over central North America were associated with moderating temperatures.

days at a time. The strong ridge in the Atlantic prevented the cold air from reaching the Northeast, and above normal heights in the Southern Plains coupled with below normal heights in north-central Canada hindered the transport of much cold air southward, as a strong confluence zone was established over the Northern States (figs. 1 and 2).

Over the central part of the Nation, the warmest weather relative to normal, and even in an absolute sense in some localities, occurred during the last half of the month, when height falls off the west coast and rises over the Plains and Lakes combined to strengthen the flow of mild Pacific and Mexican air into the country (fig. 4), thus ending several months of below normal temperatures in the central part of the country. (See [1] and previous monthly articles.) This warming probably represents the often-observed November reversal discussed by Namias [3], which is related to minimum persistence of temperature anomalies at that time of year.

Precipitation during November 1966 was heavy throughout the West, in response to stronger than normal cyclonic activity off the coast and southerly onshore anomalous flow (fig. 2). It was especially heavy in central California where more than three times the normal amount was observed (fig. 7). Red Bluff and Mt. Shasta both reported their third wettest November of record. The rains in California were generally beneficial, ending several months of drought.

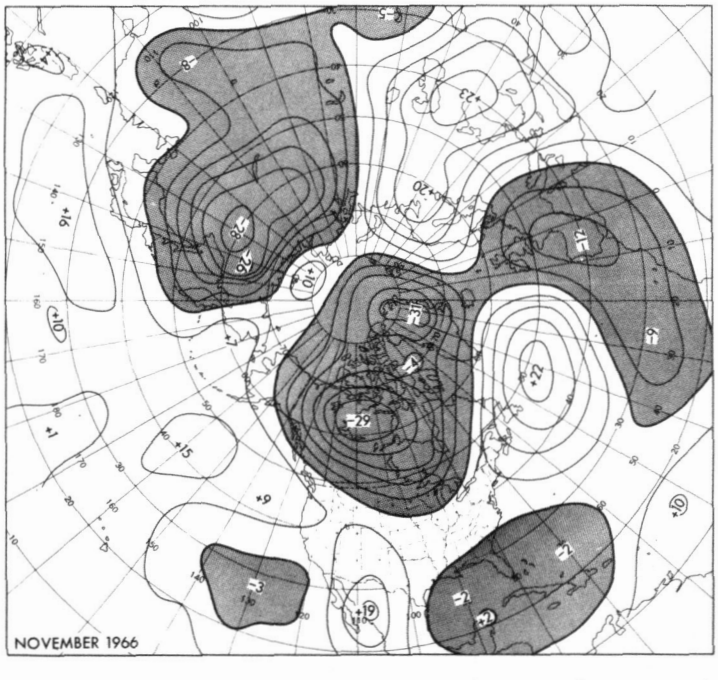


FIGURE 5.—Mean 1000-700-mb. thickness departure from normal (tens of feet) for November 1966. Colder than normal areas are shaded. Arctic air was largely contained over Canada during the month as a whole.

Most of the middle of the Nation had less than half the normal November precipitation. San Antonio, Tex., Roswell, N. Mex., and Pueblo, Colo., reported only traces, and these and several other stations reported one of the driest Novembers of record. Above normal 700-mb. heights and the absence of appreciable cyclonic activity or moisture transport from the Gulf contributed to the dryness.

Heavy precipitation up to twice the monthly normal in the Great Lakes area was due largely to storms at the beginning and end of the month. These developments were related to circulation patterns too transitory to appreciably affect the monthly mean pattern, other than to give a weak 20-ft. below normal center near Lake Michigan (fig. 2). Youngstown, Ohio, and Muskegon and Sault Ste. Marie, Mich., reported their wettest Novembers of record.

Abnormal dryness prevailed along the southeast coastal plain, but in contrast, Nantucket, Mass., reported its wettest November of record.

3. WEEKLY CIRCULATION AND WEATHER

OCTOBER 31–NOVEMBER 6

The most widespread and extreme weather situation of the month occurred during the first week, when energy dispersion from the first strong fall deepening of the Asiatic coastal trough at the end of October amplified the planetary waves. The trough over North America reached its maximum weekly depth with heights 460 ft. below normal over the Great Lakes (fig. 8A, B). In response to deepening over the continent, the ridge over the Atlantic also reached its maximum strength of 830 ft. above normal.

A deep trough was also observed over Europe, partly in response to the amplification of the planetary waves and partly due to a pre-existing system which produced the worst floods for centuries in northern Italy. The height anomaly pattern for November 1–5 over Europe (not shown) was similar to that of the month as a whole (fig. 2) except that the negative center was 570 ft. below normal, resulting in an extremely strong southerly anomalous flow in the Italian area. Surface winds were strong from the south and southeast, blowing along the length of the Adriatic Sea and piling its waters up at the northern end, thereby adding a tidal effect to the flooding from rain-swollen rivers.

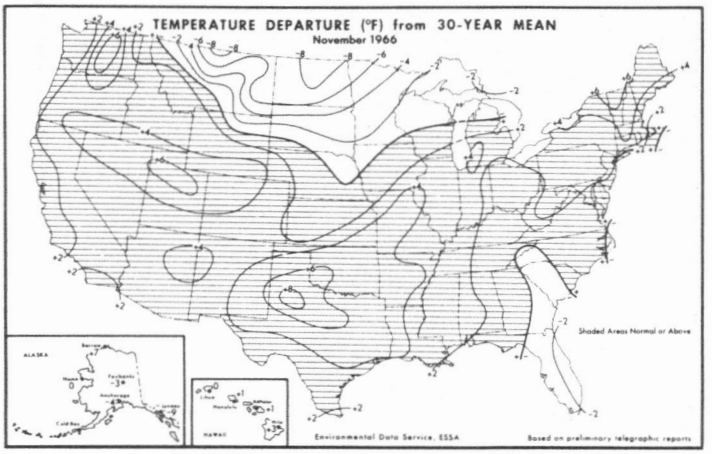


FIGURE 6.—Departure of average surface temperature from normal (° F.) for November 1966 (from [4]). Except for the North Central States and extreme Southeast, the entire country was warmer than normal.

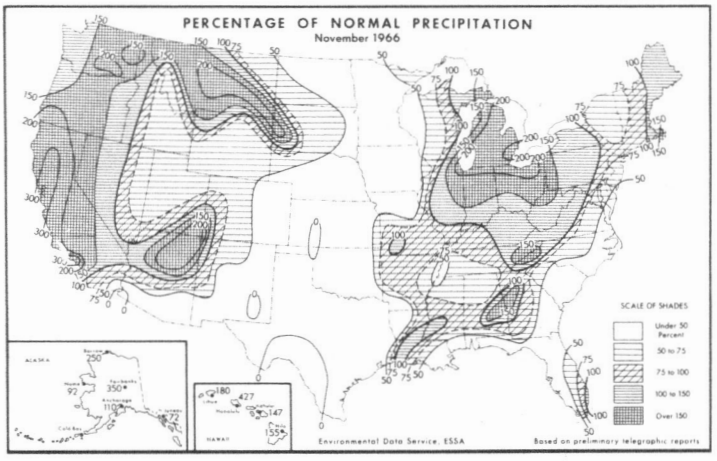


FIGURE 7.—Percentage of normal precipitation for November 1966 (from [4]). Heavy precipitation fell along nearly the entire west coast, parts of the Columbia River Basin and Rockies, and in the southern Great Lakes area.

TABLE 1.—*Record low daily minimum temperatures and coldest so early in the season established during November 1966*

City	Date	Temperature (°F.)
Concordia, Kans.	2	*11
Topeka, Kans.	2	*15
Roswell, N. Mex.	2	†18
Tulsa, Okla.	2,3	20,21
Fort Smith, Ark.	3	*15
Little Rock, Ark.	3,4	*21,28
Jackson, Miss.	3	17
Vicksburg, Miss.	3	27
Meridian, Miss.	3,4	*18,23
New Orleans, La.	2,3,4	37, *30,38
Mobile, Ala.	3	26
Nashville, Tenn.	4	*22
Chattanooga, Tenn.	4	22
Fort Myers, Fla.	4	*42
Tampa, Fla.	4	*36
Jacksonville, Fla.	4	31
Birmingham, Ala.	4	25
Atlanta, Ga.	4	24
Macon, Ga.	4,5	27,30
Charleston, S.C. (airport)	4	†27
Charlotte, N.C.	4	*22
Norfolk, Va.	5	30
Lansing, Mich.	4	*9
Casper, Wyo.	8	*−8
St. Cloud, Minn.	12	*−24
Duluth, Minn.	12	*−6
Minneapolis-St. Paul, Minn.	12	*−4

*Also coldest so early in the season.
†Equaled coldest so early in the season.

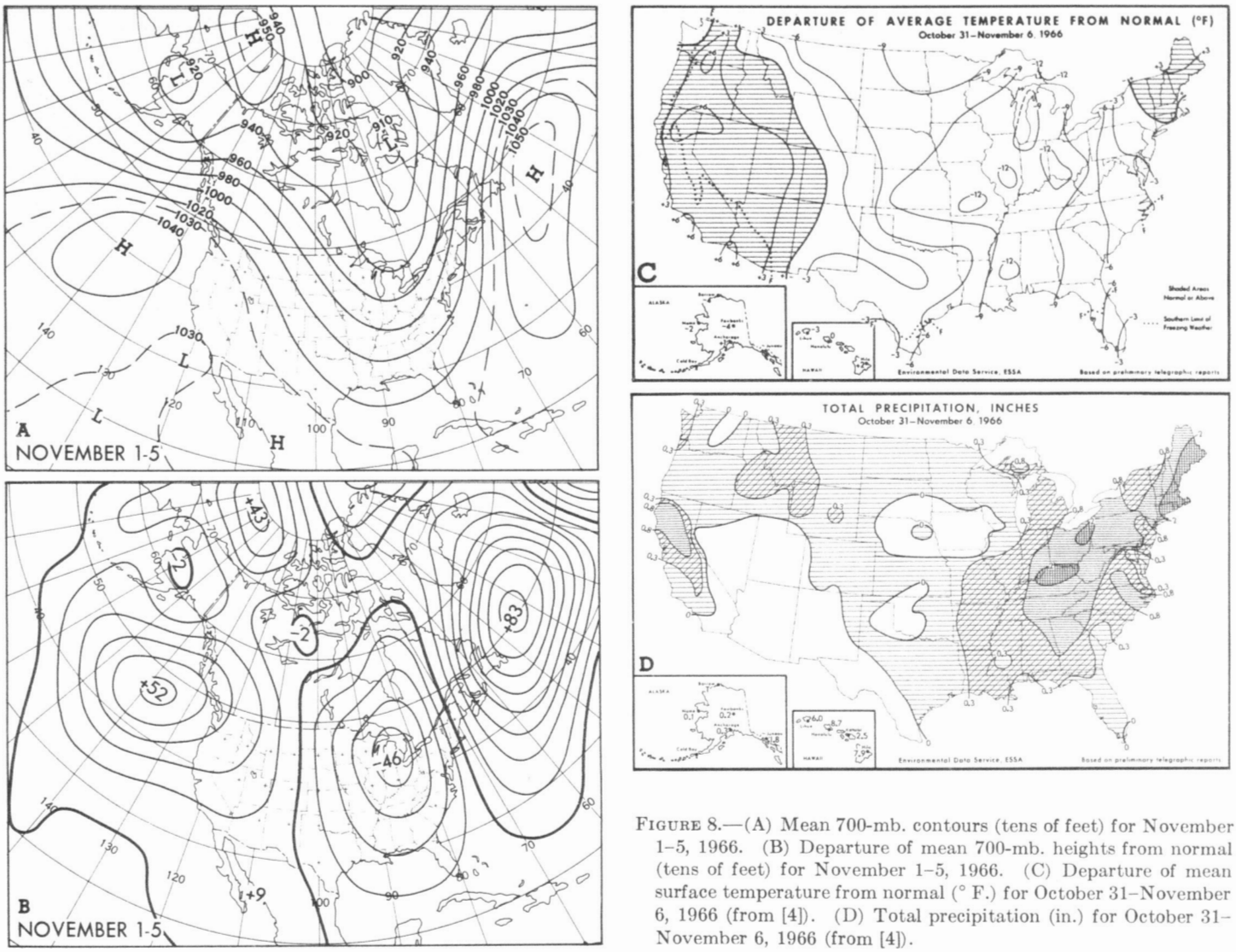


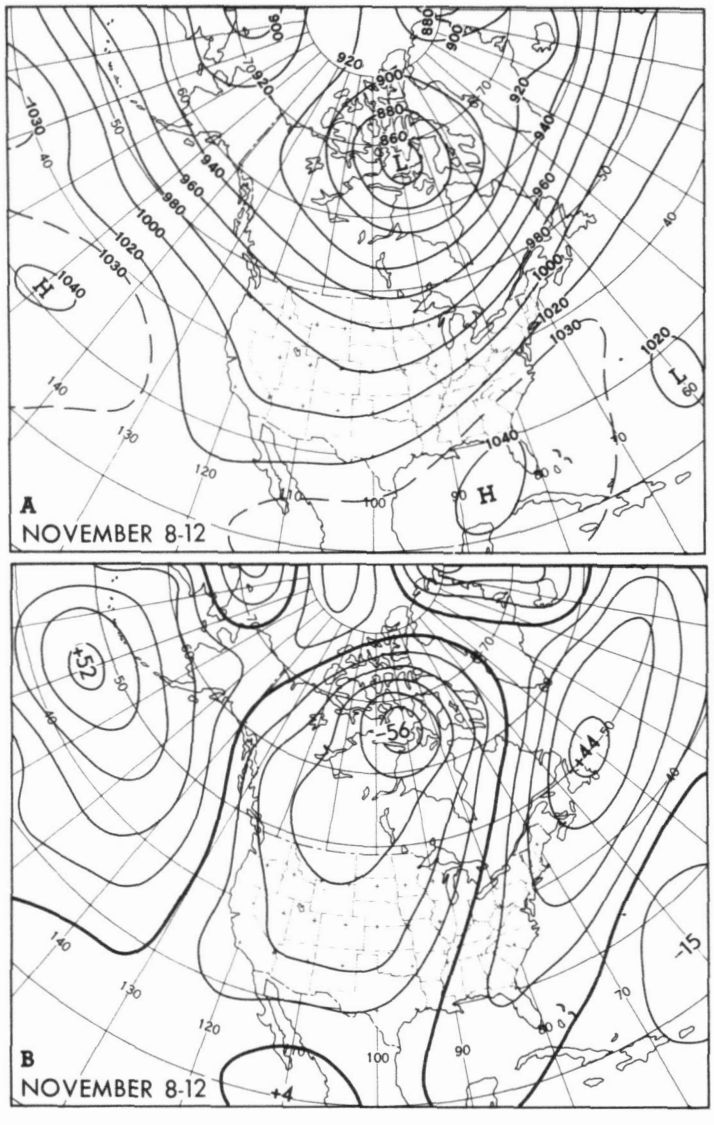
FIGURE 8.—(A) Mean 700-mb. contours (tens of feet) for November 1–5, 1966. (B) Departure of mean 700-mb. heights from normal (tens of feet) for November 1–5, 1966. (C) Departure of mean surface temperature from normal (° F.) for October 31–November 6, 1966 (from [4]). (D) Total precipitation (in.) for October 31–November 6, 1966 (from [4]).

The strongly amplified flow over the United States resulted in weekly temperatures as much as 12° F. below normal over parts of the Midwest and South, and more than 6° F. above normal in some sections of the Far West (fig. 8C). Strong easterly anomalous flow with above normal 700-mb. heights produced Santa Ana conditions along the coast of central and southern California (fig. 8B). Maxima of 101° F. on November 1 at Los Angeles and Long Beach, 97° F. at San Diego, and 86° F. at San Francisco were the highest ever recorded in November and for so late in the season. Temperatures of 86° F. on the first and second of the month also set similar records at Sacramento.

Below normal heights and northerly anomalous flow gave record-breaking cold to much of the South (table 1). The unusual cold weather was just one aspect of an intense early-season storm which moved from near Mobile, Ala., on the 1st along a track just west of the Appalachians to near James Bay on the 4th. Heavy precipitation fell over the Ohio Valley and the New England coastal area (fig. 8D), where the 4.93 in. at Nantucket on the 3d was the second greatest 24-hr. total in the history of the station. As the cold front swept eastward, it triggered small tornadoes near Raleigh, N.C., and Richmond, Va.

Much of the precipitation was in the form of snow in the Ohio Valley and Great Lakes area. Snowfall totals ranging from 5 to 8 in. on the 2d set records for 24-hr. November snowfall or heaviest snow so early in the season at many localities from Nashville, Tenn., to South Bend, Ind. Louisville, Ky., reported 13 in., and up to 2 ft. of snow piled up in the southern suburbs of Buffalo, N.Y., on the 3d. Snow pellets were observed as far south as Mobile, Ala.—a rarity there at any time of the year.

Extremely heavy rains fell over most of the Hawaiian Islands during the first week of the month (fig. 8D). The cause was a low-latitude cyclone which appeared to be of the Kona type, even though this type of storm does not ordinarily occur until well into the winter season.



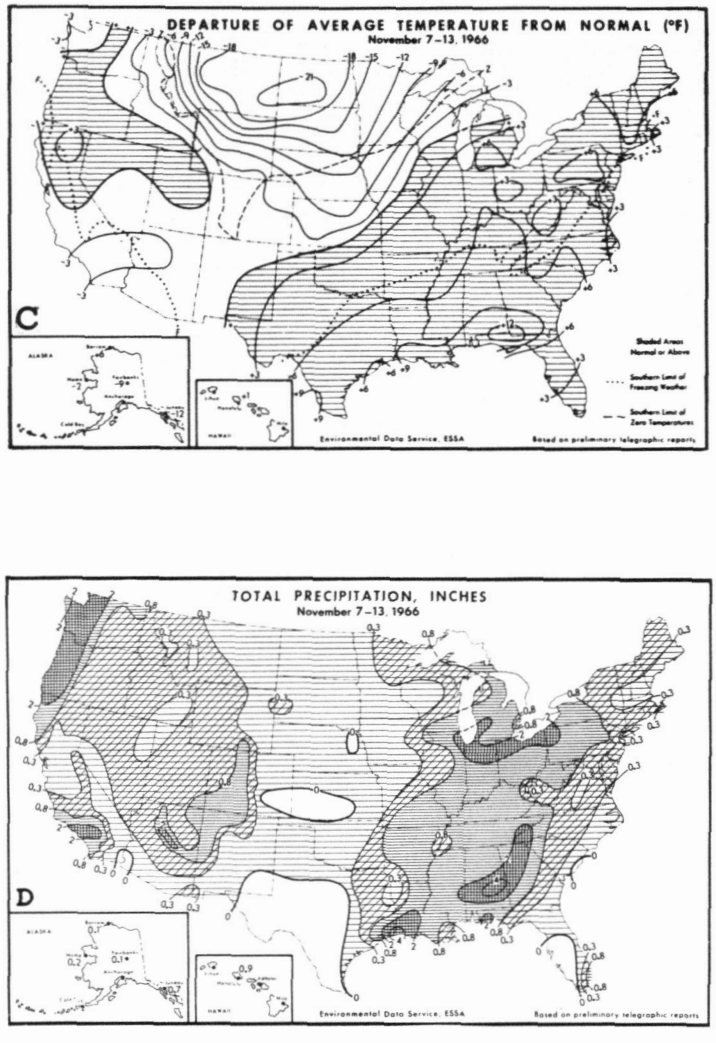


FIGURE 9.—Same as figure 8, (A) and (B) for November 8–12, 1966; (C) and (D) for November 7–13, 1966 (from [4]).

NOVEMBER 7–13

The circulation and weather over the country changed rapidly during the second week of November, with the temperature undergoing an almost complete reversal from the first week. A trough moved in over southern California replacing the anticyclonic conditions, and heights rose over the Southeast while remaining below normal over the Northern Plains and Great Lakes (fig. 9A, B). As a consequence, a confluence zone was set up in the middle of the country separating bitter cold Arctic air over the Northern Plains from mild Gulf air which covered most of the East and South (fig. 9C). At the same time that several stations in North Dakota and Minnesota were setting sub-zero coldest-so-early-in-the-season records (table 1), temperatures along the east coast from Virginia to New Hampshire were breaking daily records for warmth.

Precipitation was again heavy in the Midwest (fig. 9D)—a result of the warm, humid air which had moved into the area, although no major storm systems were south of the Great Lakes at this time. Rockford, Ill., had 6 days with thunderstorms during November 1966, as compared with a normal of one. Three of these occurred during the second week and three later in the month during a second warm spell. Heavy rains which fell over southern California as the trough moved inland produced a new 24-hr. November record of 3.85 in. at Los Angeles Civic Center on the 7th, the same day that a small tornado was observed east of the airport station.

NOVEMBER 14–20

During the third week of the month a deep trough formed off the west coast in response to strong blocking over the Aleutians (fig. 10A, B). Heights were above normal over most of the country as mild air of Pacific origin overspread the Nation. Greatest weekly temperature departures (as much as 12° F. above normal) were observed over the Plateau, Central Rockies, and Southern Plains (fig. 10C).

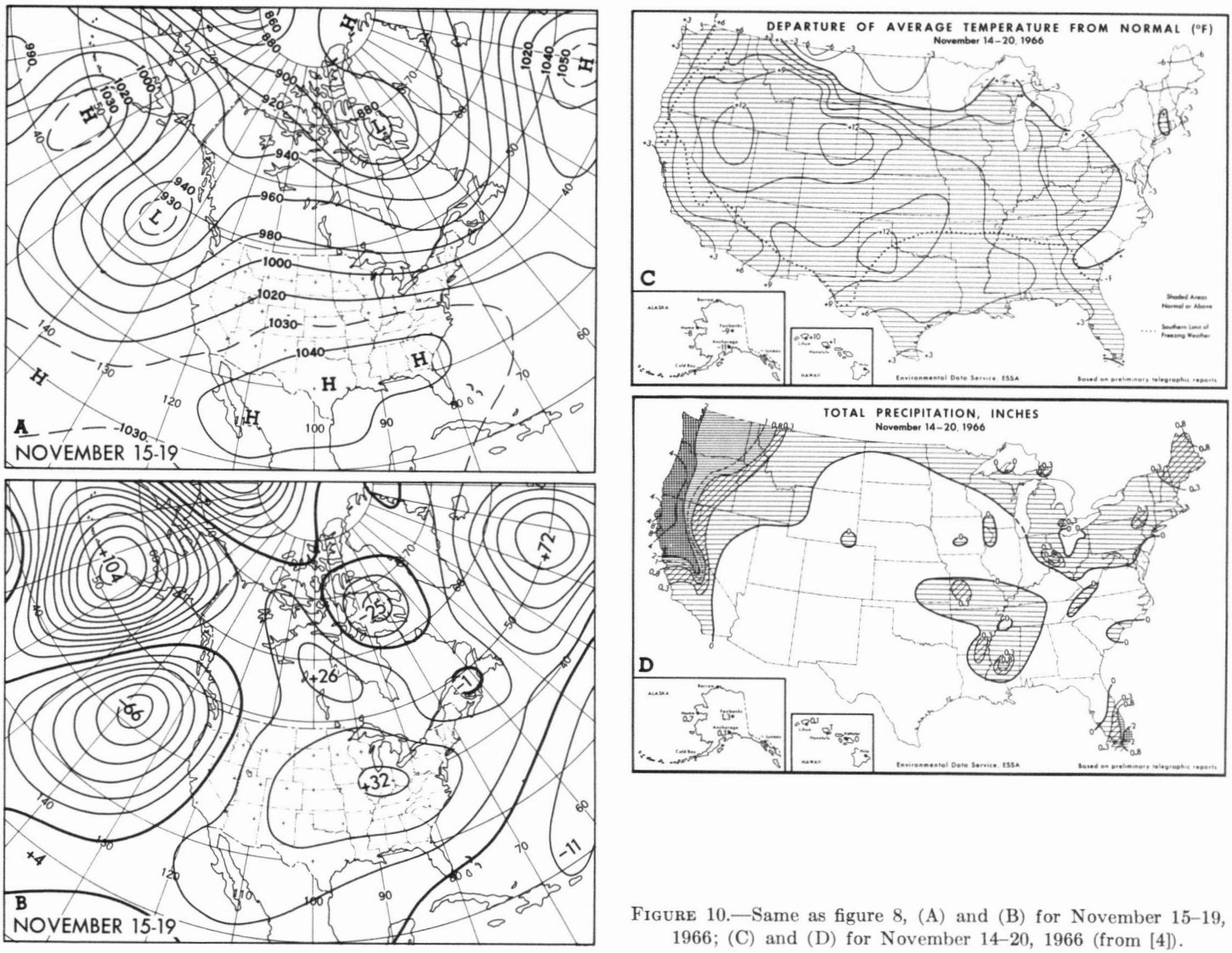


FIGURE 10.—Same as figure 8, (A) and (B) for November 15–19, 1966; (C) and (D) for November 14–20, 1966 (from [4]).

Since the major source of moisture for air entering the country was the Pacific, heavy rains were confined to the west coast, particularly Oregon and northern California (fig. 10D), where as much as 8 in. fell during the week. A small area of heavy precipitation was also observed over southeastern Florida, where flow from the Atlantic was stronger than normal (fig. 10B). The Nation's midsection was predominantly dry, under above normal heights.

NOVEMBER 21–27

The warm weather on November 1966 reached its peak during Thanksgiving week as the trough off the west coast moved into the Plateau and the anomalous flow turned to southerly over the Plains (fig. 11A, B). Weekly temperatures averaged in excess of 18° F. above normal over central Missouri (fig. 11C). The warm air set many daily temperature records over a wide area from Idaho on the 20th to the east coast on the 27th. Maxima in the 70's exceeded previous daily records for four consecutive days on November 21–24 at Kansas City, Mo. The 78° F. recorded on the 21st was also the highest ever observed so late in the season.

Temperatures along the Atlantic Coastal Plain were slow to rise as a cold polar High which moved into the region at the beginning of the week stagnated over the area. Although the air mass was warmed aloft by subsidence and advection, strong radiation conditions led to the formation of an extensive low-level inversion. Smog developed in this layer, reaching varying levels of severity at several cities. Fortunately the Thanksgiving holiday with its attendant shutdown of much industry and lessened commuter traffic prevented a serious condition from reaching the danger level in New York City and the surrounding suburbs. Showers and surface advection of warm air cleared most of the smog away by the end of the week.

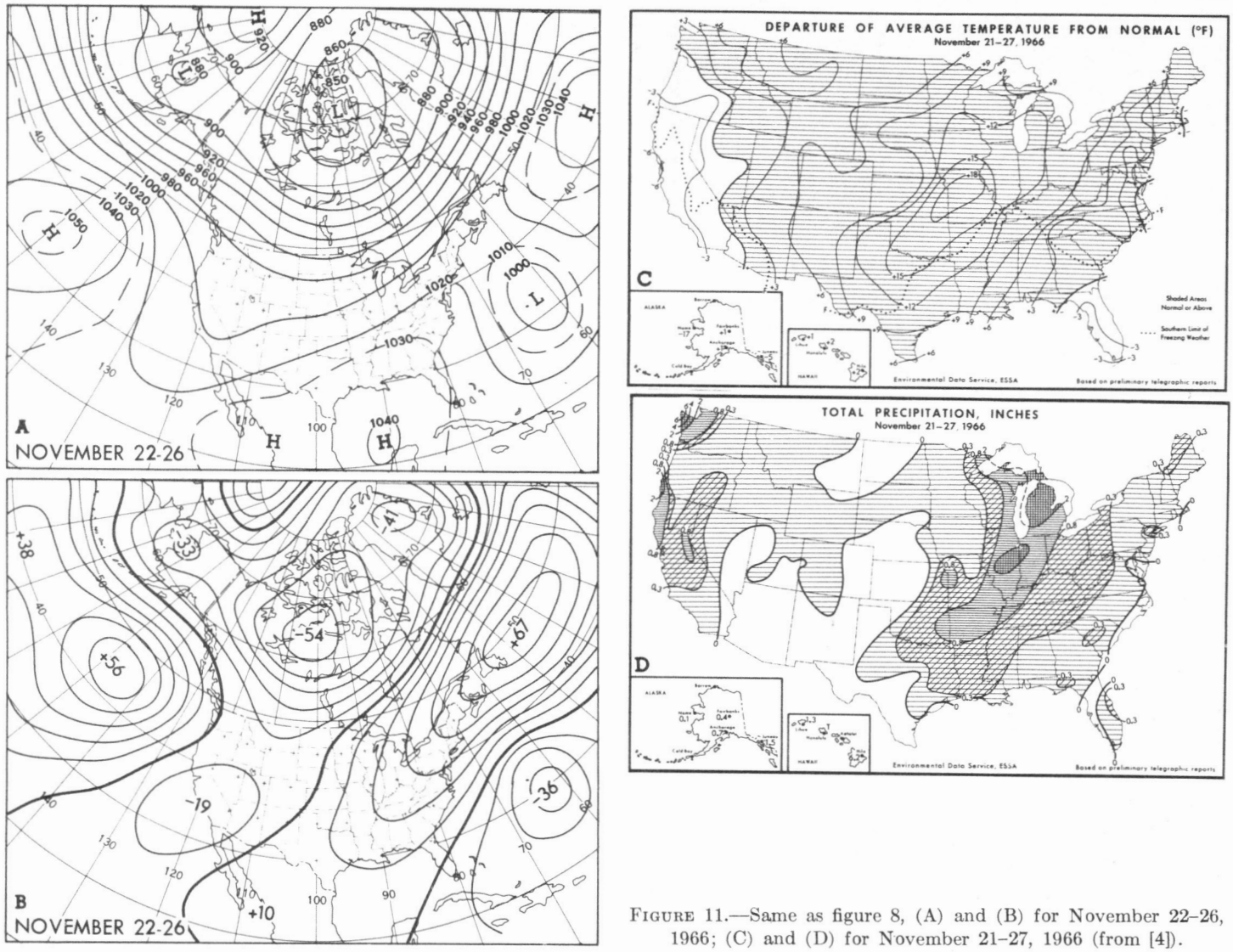


FIGURE 11.—Same as figure 8, (A) and (B) for November 22–26, 1966; (C) and (D) for November 21–27, 1966 (from [4]).

The closing days of the month were marked by another intense storm system in the Great Lakes area which was actually made up of two separate cyclones. Together, these storms produced precipitation amounts in excess of 2 in. in some areas (fig. 11D) as they fed on moisture-rich Gulf air. At the end of the week, cold air began to move rapidly into this storm complex, although too late to show in the weekly temperature anomalies. The storms produced heavy snow and blizzard conditions over parts of Michigan, where Alpena reported 15 in. of snow within 24 hr., a new record. When added to other storms, it contributed to a new November monthly snowfall record of 30.5 in. of snow.

The strong pressure gradient northwest of the storm center produced gusts of hurricane force over Lake Huron, where an ore carrier broke in two and sank with the loss of all but one of the crew. An automobile ferry was blown aground in southern Lake Michigan during the same storm.

4. FALL 1966

The mean seasonal circulation for fall 1966 (fig. 12) shows a stronger-than-normal development of the Great Lakes-Ohio Valley trough, leading to southerly anomalous flow along the east coast. This was associated with welcome rains which at least temporarily relieved the severe drought (fig. 14). Namias [5] has shown that the recent east coast drought has been primarily a spring and summer phenomenon, with frequent interruptions in the fall and winter seasons.

The largest seasonal anomaly in the western half of the Northern Hemisphere was the 210 ft. above normal development of the mid-Atlantic ridge. This also contributed to greater than normal advection of tropical air from the Atlantic toward the eastern United States. Downstream effects from the strong Atlantic ridge led to cool, wet weather with frequent storms over western and

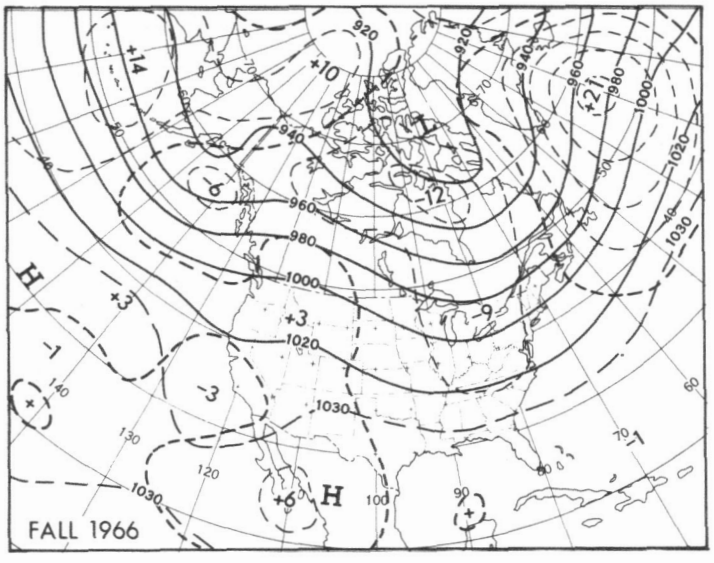


FIGURE 12.—Mean 700-mb. contours (solid) and departure from normal (short dashed) (both in tens of feet) for fall (September, October, November) 1966.

central Europe, culminating in the disastrous Italian floods.

The temperature departure from normal during fall 1966 over the United States (fig. 13) was typically related to the circulation anomalies. Greatest relative warmth (temperatures as much as 4° F. above normal) was in the Columbia River Basin, close to the 30-ft. positive height anomaly center shown in figure 12. Largest negative temperature departures were observed over the Northern Plains and the Ohio-Tennessee Valley area. Northerly anomalous flow contributed to the cold weather in the Plains, and below normal heights accompanied the southern area of cold. Heavy precipitation, much of which fell in the earlier part of the season, may have contributed to the abnormal coolness in the Tennessee Valley area.

Heavier-than-normal precipitation covering much of the East (fig. 14) was related to the Midwest trough. Dryness over the Plains was associated with greater-than-normal northerly flow, and the dry area along the southeast coast was probably a rain-shadow effect in response to stronger-than-normal westerly flow across the southern Appalachians (fig. 12). Heavy precipitation over South Dakota and the west coast was apparently related to relatively transitory regimes not reflected strongly in the seasonal mean circulation pattern.

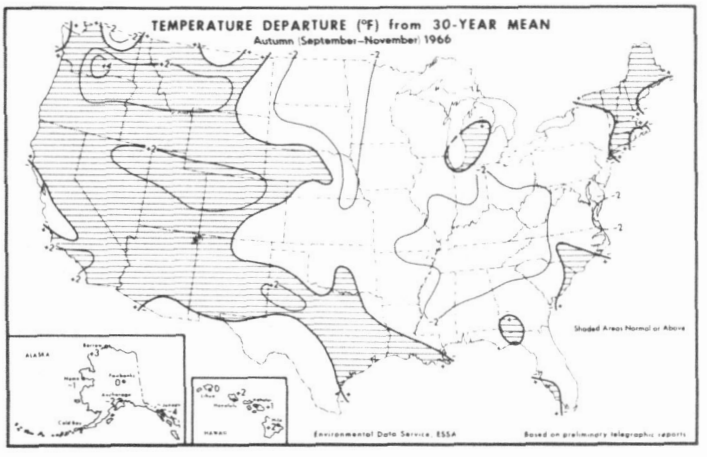


FIGURE 13.—Departure of average surface temperature from normal (° F.) for fall (September, October, November) 1966, (from [4]).

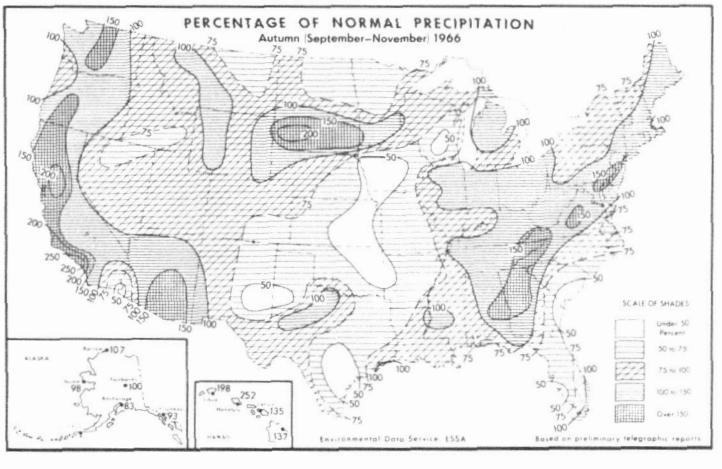


FIGURE 14.—Percentage of normal precipitation for fall (September, October, November) 1966, (from [4]).

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